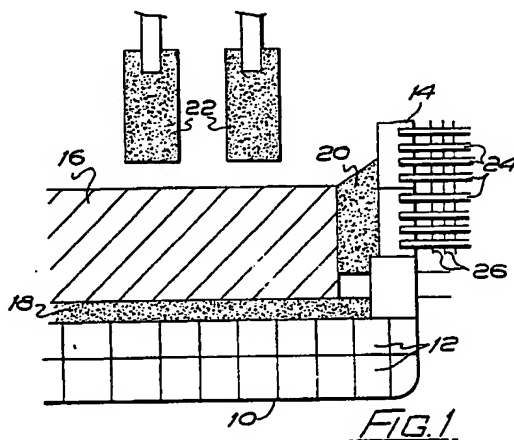
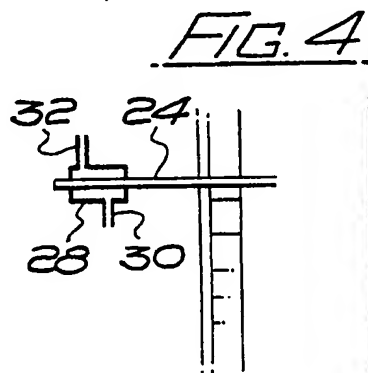
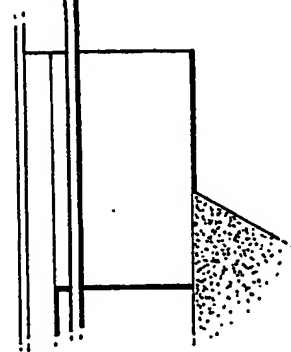
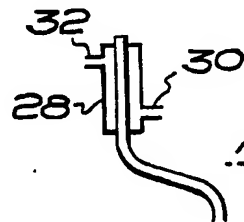
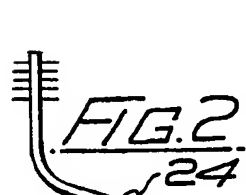
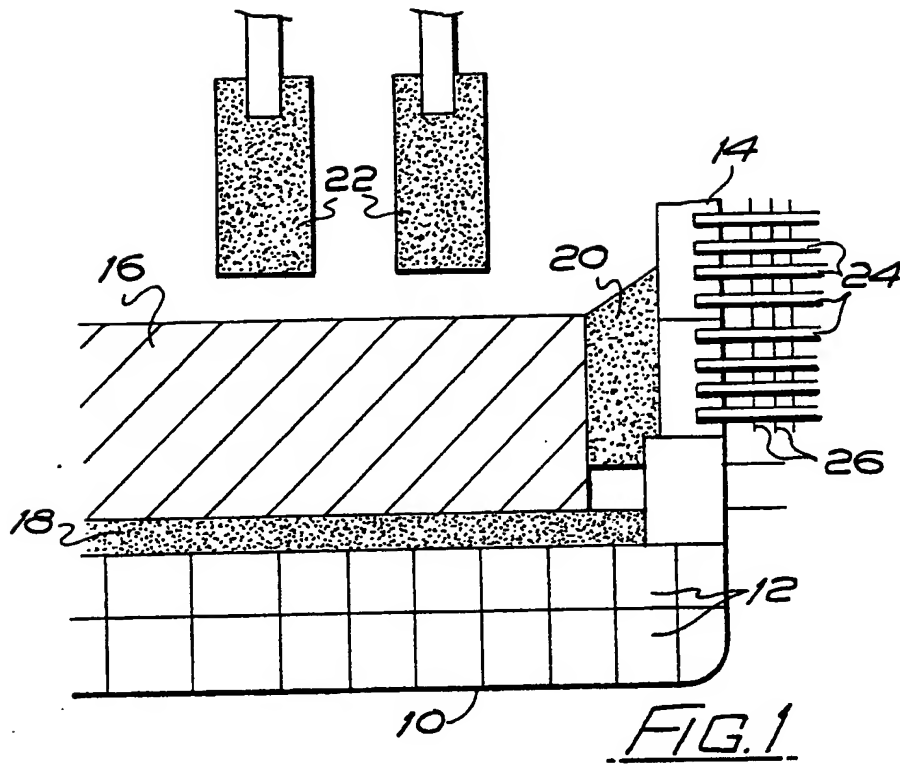


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(54) Aluminium manufacture

(57) The manufacture of aluminium in an electric cell is characterised by providing heat pipes 24 extending into the carbon blocks 14 of the cell wall or walls to remove heat, and varying the rate of heat removal through the cell wall by adjusting the positions of the heat pipes, or varying the rate at which their condenser ends are cooled. In this way the bath temperature is regulated without having to reduce the rate of production.





## SPECIFICATION

## Aluminium manufacture

5 The invention relates to aluminium manufacture and has for its object to provide an improvement therein.

Aluminium is generally made in a so-called Hall-Heroult electric cell. An electric cell for the manufacture of aluminium has a horizontal carbon floor lining constituting a cathode, at least one carbon anode extending vertically downwards towards the cathode, and carbon lined side walls. In use of the electric cell alumina is dissolved in a bath of molten cryolite, and decomposed by a very large electric current. It has been proposed to make the lining of the wide walls of high thermal conductivity carbon blocks but these have the disadvantage of being of low electrical resistivity so that the required flow of high electrical energy from the carbon anode or anodes to the floor of the cell is affected, that is to say is deflected towards the side walls. It has been found advantageous to control the temperature of the bath of aluminium for optimum efficiency of production, and also to ensure that a crust of frozen cryolite is always present on the side walls. This is to both seal the side walls and decrease wear of the lining. Both of these factors can affect productivity. It has previously been necessary to reduce bath temperature to ensure cryolite formation by raising the anode with consequential loss of production.

According to one aspect of the invention, there is provided a method of making aluminium by smelting in an electric cell, the method including the step of varying the rate of heat removal through the wall or walls of the cell in dependence upon the temperature or temperature ranges within the cell. The rate of heat removal may be automatically controlled by heat sensors or by other means in the furnace wall or walls. The heat removal will preferably be effected by the use of heat pipes (that is to say low pressure boiling/condensing units), and in this case the method may include the step of automatically controlling the flow of a cooling medium over condenser (heat removal) ends of said heat pipes. Alternatively, the method may include the step of adjusting the positions of said heat pipes, that is to say to adjust the distance by which their evaporator (heat input) ends project into the side wall or walls of the cell, under the control of or with reference to heat sensors.

According to a further aspect of the invention, there is provided an electric cell for the manufacture of aluminium, the cell having a horizontal carbon floor lining constituting a cathode, at least one carbon anode extending vertically downwards towards the cathode, and carbon lined side walls, means being provided for varying the rate of heat removal through the wall or walls of the cell in dependence upon the temperature or temperature ranges within the cell. The means provided for varying the rate of heat removal may include heat sensors in the cell wall or walls or elsewhere in the cell. Heat pipes (that is to say low pressure boiling/condensing units) will preferably extend into the furnace wall or walls for

extracting heat from the cell, and in this case the varying of the rate of heat removal may be brought about by means for controlling the flow of a cooling medium over condenser (heat removal) ends of said heat pipes. Alternatively, the varying of the rate of heat removal may be brought about by means for adjusting the positions of said heat pipes, that is to say by means for adjusting the distance by which their evaporator (heat input) ends project into the side wall or walls of the cell. The varying of the rate of heat removal may be brought about automatically, the control of the heat sensors in said wall or walls.

In order that the invention may be fully understood and readily carried into effect, the same will now be described, by way of example only, with reference to the accompanying drawings, of which:-

Fig. 1 is a sectional side elevation of an electric cell embodying the invention for the production of aluminium; and

Figs. 2 to 4 are views which will be referred to when describing possible modifications.

Referring now to Fig. 1 of the drawings, the electric cell there illustrated for the production of aluminium includes an outer casing consisting of a steel box 10 with a base of insulating brick 12 and carbon side walls 14 forming a container and support. Inside the lined casing, carbon blocks are jointed together with a suitable paste to form the floor 16 of a shallow bath, the floor blocks constituting a cathode when the cell is in operation. The blocks forming the floor are laid on alumina powder or other insulating material 18 and the space between the floor blocks and the carbon side walls is filled with ramming material 20.

An anode construction is constituted by a plurality of pre-baked carbon blocks 22 (only two of which are shown in Fig. 1) extending vertically downwards from a carrier (not shown). When the cell is in use, an electrolyte consisting largely of molten cryolite is contained in the shallow bath formed by the carbon blocks 14 and a large electric current is passed from the anode to the cathode. The cell operates at a temperature in the region of 1000°C.

Means are provided for varying the rate of heat removal through the walls of the cell in dependence upon the temperature or temperature ranges within the cell. Heat removal means include a plurality of heat pipes 24 (that is to say low pressure boiling/condensing units) which extend into the furnace walls for extracting heat from the cell, said heat pipes being grouted into the carbon side walls 14 to ensure good heat conductivity. The varying of the rate of heat removal by said heat pipes is brought about automatically by means for controlling the flow of a cooling medium over the condenser (heat removal) ends of said heat pipes which project outwards from the wall of the cell. In the drawing, the condenser (heat removal) ends of the heat pipes are shown to extend through a bank of cooling fins 26 spaced from the outer walls of the cell. A motor driven fan (not shown) is provided for producing a forced flow of cooling air along the spaces between the cooling fins. Heat sensors in the cell walls, or other means (not shown), control the switching on

and the switching off of the motor driven fan. Consequently, there is a two-stage rate of cooling, that is to say a relatively low rate of heat removal when the flow of cooling air over the condenser (heat removal) ends of the heat pipes is by convection currents of air only and a relatively higher heat removal rate when the forced flow of cooling air is brought about.

Thus there is provided an electric cell for the production of aluminium which it is thought will be an advance on such cells previously used because greater control of the temperature within the cell will be possible.

However, various modifications may be made. For example, the varying of the rate of heat removal from the cell may be brought about not by means for switching on or off the motor driven fan for blowing air between the bank of cooling fins 26 but by means for adjusting a system of baffles by means of which the forced flow of cooling air can be made fully or less fully effective. Alternatively, instead of being effected by means for controlling the flow of the cooling medium over the condenser (heat removal) ends of the heat pipes, the means for varying the rate of heat removal through the walls of the cell may be effected by means for automatically adjusting the positions of the heat pipes, that is to say for automatically adjusting the distance by which their evaporator (heat input) ends project into the side walls of the cell, such adjusting means again preferably being under the control of the heat sensors in the cell walls or elsewhere in the cell. In this latter case, the evaporator (heat input) ends of the heat pipes will be slidably mounted in respective metal sleeves and said metal sleeves will be grouted into the carbon side walls of the cell to ensure good heat conductivity.

Various other modifications may be made. For example, in Fig. 2 there is illustrated an arrangement in which the heat pipes 24 extend vertically through the carbon lining of the side walls of the cell. The upper ends of the heat pipes are shown extending through cooling fins. In Fig. 3 there is illustrated a possible modification of the arrangement just described, this being the water cooling of the condenser (heat removal) ends of the heat pipes, a water jacket 28 being shown surrounding an outer end of one of the heat pipes with flow and return pipes 30 and 32 extending into it for the flow of cooling water therethrough. A similar arrangement is shown in Fig. 4 where a water jacket 28 is shown to surround an outer end of a heat pipe 24 extending horizontally through the furnace wall. It will of course be understood that in both these cases the water jacket illustrated may be relatively small and be associated with a single heat pipe or may be of elongate shape so that a plurality of heat pipes can extend into or through it. If water cooling is used, the means for varying the rate of heat removal through the walls of the cell may be by valve means so arranged that, to reduce the rate of heat removal, some of the hot water flowing from the water jacket or water jackets is re-circulated. Consequently, the heat difference between the opposite ends of the heat pipes will be reduced so that the heat pipes are caused to work at less than their maximum capacity. It will obviously

be preferable for the rate of heat removal to be varied automatically, that is to say, for example, for a fan to be switched on and off or for heat pipes to be adjusted in position under the direct control of heat sensors. However, it would not be outside the scope of the invention for such switching on or off of a fan or adjustments in position of heat pipes to be effected manually by an operative referring to a temperature gauge connected to the heat sensors.

It has been found that many heat pipes do not work at their optimum efficiency when located horizontally. Consequently, it will be understood that in the arrangements illustrated in Figs. 1 and 4 it would be advantageous to install each heat pipe with its condenser (heat removal) end higher than its evaporator (heat input) end that is to say to tilt the heat pipes to some extent, to improve their efficiency.

The positioning of the individual heat pipes will be quite critical. If the evaporator (heat input) ends of the heat pipes are located too near the interior of the electric cell they will quickly burn out. Conversely, if too far away from the interior of the cell they will not operate effectively to extract the required amount of heat.

The number of heat pipes and their spacing will be chosen in accordance with the particular electric cell. This, and also the spacing of individual heat pipes from the cell interior, and a suitable angle of tilt are factors which can be determined by trial and experiment. Guidance as to the number of heat pipes can be obtained by estimating the amount of heat to be removed from the cell, and calculating from the heat transfer properties of the pipes employed (which are usually published by the manufacturers of the pipes, or can be measured). Temperatures within the cell wall can be measured, e.g. with a thermocouple inserted into a small bore in the wall, and these observed temperatures will guide in choosing the spacing of the evaporator (heat input) ends from the cell interior.

#### CLAIMS

1. A method of making aluminium by smelting in an electric cell, the method including the step of varying the rate of heat removal through the wall or walls of the cell in dependence upon the temperature or temperature ranges within the cell.

2. The method according to claim 1, in which the rate of heat removal is automatically controlled by heat sensors or by other means in the furnace wall or walls.

3. The method according to either one of the preceding claims, in which the heat removal is effected by the use of heat pipes (that is to say low pressure boiling/condensing units).

4. The method according to claim 3, including the step of automatically controlling the flow of a cooling medium over condenser (heat removal) ends of said heat pipes.

5. The method according to claim 3, including the step of adjusting the positions of said heat pipes, that is to say to adjust the distance by which their evaporator (heat input) ends project into the side wall or walls of the cell, under the control of or with reference to heat sensors.

6. An electric cell for the manufacture of aluminium, the cell having a horizontal carbon floor lining constituting a cathode, at least one carbon anode extending vertically downwards towards the cathode, and carbon lined side walls, means being provided for varying the rate of heat removal through the wall or walls of the cell in dependence upon the temperature or temperature ranges within the cell.
7. An electric cell according to claim 6, in which the means provided for varying the rate of heat removal include heat sensors in the cell wall or walls or elsewhere in the cell.
8. An electric cell according to either one of claims 6 and 7, in which heat pipes (that is to say low pressure boiling/condensing units) extend into the furnace wall or walls for extracting heat from the cell.
9. An electric cell according to claim 8, in which the varying of the rate of heat removal is brought about by means for controlling the flow of a cooling medium over condenser (heat removal) ends of said heat pipes.
10. An electric cell according to claim 8, in which the varying of the rate of heat removal is brought about by means for adjusting the positions of said heat pipes, that is to say by means for adjusting the distance by which their evaporator (heat input) ends project into the side wall or walls of the cell.
11. An electric cell according to either one of claims 9 and 10, in which the varying of the rate of heat removal is brought about automatically, the control or adjusting means, as the case may be, being under the control of the heat sensors in said wall or walls.
12. An electric cell for the manufacture of aluminium, provided with means for varying the rate of heat removal through the wall or walls of the cell, said means being constructed, arranged and adapted to operate substantially as hereinbefore described with reference to and as illustrated by Fig. 1, Fig. 2, Fig. 3 or Fig. 4 of the accompanying drawings.